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② QUALITY EVALUATION LABORATORY
~~UNITED STATES~~ NAVAL AMMUNITION DEPOT,
CRANE, INDIANA

N64-16717

Code 1

(NASA CR-55828;

EVALUATION PROGRAM
FOR
NICKEL CADMIUM SEALED CELLS.

ACCEPTANCE TEST
OF
GENERAL ELECTRIC COMPANY
3.0 AMPERE HOUR CELLS

QE/C-63-321)

H. M. Schultze
23 August 1963

OTS: PRICE

XEROX

\$ 260 ph

MICROFILM

\$ 0.86 MF

PREPARED UNDER THE DIRECTION OF

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(NASA Order W-11252-3)

ENCLOSURE (1)

aka 4 ↑
index as above

REPORT BRIEF

NASA CR 63328

SEALED NICKEL CADMIUM BATTERY PROGRAMOFCELLS DESIGNED FOR USE IN SPACECRAFT

- Ref: (a) National Aeronautics and Space Administration Purchase Order Number W11,252B
(b) NASA ltr BRA/VBK/pad of 25 September 1961 to CO NAD Crane w/BUWEPS first end FQ-1:WSK of 2 October 1961
(c) Preliminary Work Statement for Battery Evaluation Program of 25 August 1961

I. TEST ASSIGNMENT BRIEF.

A. In compliance with references (a) and (b), evaluation of Sealed Nickel Cadmium Cells was begun according to the program outline of reference (c).

B. The object of this evaluation program is to gather specific information concerning sealed nickel cadmium cells designed for use in spacecraft. Information concerning the performance characteristics and limitations, including cycle life under various electrical and environmental conditions, will be of interest to power systems designers and users. Cell degradation, including causes of failure of present designs, will be of interest to suppliers as a guide to product improvement.

C. A total of 1100 cells was purchased by National Aeronautics and Space Administration (NASA) from four manufacturers, and consist of seven sample classifications ranging from 3 to 20 ampere hours.

D. The program is divided into three main sections consisting of Acceptance Tests, General Performance Tests and Cycle Life Tests.

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E. This report is the seventh of a series of seven of the Acceptance Test Section. It gives the results of the acceptance tests of 200 three ampere hour size cells supplied by General Electric Company, Gainesville, Florida. The cells are rated at 3.0 ampere hours by the manufacturer.

II. CONCLUSIONS.

A. From the results of this test, it can be concluded that:

1. The weak point of the General Electric Company 3.0 ampere hour cells is the sealing of the filler tube as evidenced by 20 leakers out of the 224 cells tested.

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2. The capacity of the cells was in the acceptable range of 3.38 to 4.08 ampere hours.

AUTHOR

III. RECOMMENDATIONS.

A. It is recommended that an improvement be made in the method of sealing the filler tube.

B. It is also recommended that improvement be made in the quality control methods of leak testing the completed cell as 9 of the 20 leaks were found by the immersion seal test.

C. It is also recommended that greater care be taken in assembling the cells. Three cells failed the cell short test and one cell had a high resistance contact that allowed the cell to charge but not to discharge.

RESULTS OF ACCEPTANCE TESTS
OF
3.0 AMPERE HOUR SEALED NICKEL CADMIUM CELLS
MANUFACTURED BY
GENERAL ELECTRIC COMPANY

I. INTRODUCTION.

A. On 16 March 1963, this activity began acceptance tests on 70 cells, the first received of a total of 224 necessary for final acceptance of the 200 required. The acceptance tests were completed on 16 August 1963.

B. The NASA purchase contract was let during April 1962 stipulating delivery within 90 days. The cells, however, were received intermittently between March 1963 and August 1963.

II. TEST CONDITIONS.

A. All acceptance tests were performed at an ambient temperature between 23° C. and 27° C. at existing relative humidity and atmospheric pressure, and consisted of the following:

1. Capacity Test.
2. Cell Short Test.
3. Immersion Seal Test.
4. Overcharge Test.
5. Litmus Leakage Test.
6. Internal Resistance Test.

B. All charging and discharging was done at constant current ($\pm 5\%$). Cells were charged in series but discharged individually.

III. CELL IDENTIFICATION AND DESCRIPTION.

A. The cells were identified by the manufacturer's serial numbers from 2-3 to 7-84, although not consecutively.

B. The 3.0 ampere hour cell is cylindrical with an average diameter of 1.25 inches and an average over-all length of 3.10 including the

positive terminal and solder tab. The average weight was 155.0 grams. Figure 1 is a photograph of a General Electric Company 3.0 ampere hour cell.

C. The cell container or can and the cell cover are made of stainless steel. The positive terminal is insulated from the cell cover by a ceramic (titanium hydride) bushing and protrudes through the bushing with a solder tab welded to the terminal. The negative terminal is a solder tab welded to the cell cover.

D. These cells, rated by the manufacturer at 3.0 ampere hours, were received in a partially discharge condition.

IV. TEST PROCEDURES AND RESULTS.

A. Capacity Test.

1. The capacity test is a determination of the cell capacity at the $c/2$ discharge rate, where c is the manufacturer's rated capacity, to a cut-off voltage of 1.00 volt per cell. The discharge was made after a 1-hour open circuit period following a 16-hour charge at the $c/10$ rate. A total of three capacity checks were made at this activity. The cells were discharged individually but were recharged in series.

2. As no capacity data was submitted by the manufacturer, it was not possible to compare the manufacturer's capacity values with those of this activity. The individual cell capacities ranged from 3.38 to 4.08 ampere hours for an average of 3.69 ampere hours. The cell capacities are tabulated in Table I in order from the highest to the lowest value. Characteristic 2-hour discharge curves are shown in Figure 2.

B. Cell Short Test.

1. The cell short test is a means of detecting slight shorting conditions which may exist because of imperfections in the insulating materials, damage to element in handling or assembly.

2. Following completion of the third capacity test, each individual cell was shorted for 16 hours. Each cell was then placed on charge at the $c/5$ rate for 1 minute followed by an open circuit stand for 24 hours, during which time voltage readings were taken every 3 hours. Any cell with voltage readings below 1.0 volt at the end of 24 hours was rejected.

3. The open circuit cell voltages 24 hours after the 1-minute charge at $c/5$ following the 16-hour shorted period, ranged from 1.19 to 1.21 volts for an average of 1.20 volts.

4. Of the 224 cells submitted to the cell short test, three were rejected. The voltage values for the 200 accepted cells are shown in Table I.

C. Immersion Seal Test.

1. The immersion seal test is a means of detecting leakage of a seal or weld. The test was performed before the Overcharge Test sequence to show if the leak was present before the overcharge sequence.

2. The cells were placed under water in a bell jar container. A vacuum of 20 inches of mercury was held for 3 minutes. Cells discharging a steady stream of bubbles were considered rejects. The cells were then washed in distilled water and dried.

3. There were nine failures out of the total of 221 cells subjected to the immersion seal test.

D. Overcharge Test.

1. The overcharge tests were performed to determine the steady state voltage at specified rates. The test specified a series of constant current charges at c/20, c/10 and c/5 rates, for a minimum of 48 hours at each charge rate or until the increase of the "on-charge" voltage was less than 10 millivolts per day.

2. The cells were monitored hourly throughout the test. Charging was to be discontinued on cells which exceeded 1.50 volts while on charge. No cells exceeded the 1.50 volts maximum.

3. The steady state voltage of each cell at the end of each 48-hour charge rate is shown in Table I. Characteristic overcharge voltage curves are shown in Figure 3.

E. Internal Resistance Test.

1. This test was performed to determine the internal resistance of the cell.

2. At the completion of the Overcharge Test, the cells were returned to the c/20 charging rate and given a short pulse (5-10 seconds) at rate of c in amperes. The cell voltage, V1, immediately prior to the pulse; and V2, 5 milliseconds after the pulse, were read on a suitable recording instrument. A CEC high speed tape recorder (28.8 inches of tape per second) was used. The internal resistance of the cell in ohms was calculated according to the following formula.

$$R = \frac{V2 - V1}{Ic - Ic/20}$$

V1 and V2 are in volts, Ic and Ic/20 are in amperes.

3. The internal resistance value for each cell is shown in Table I. The values range from 7.02 milliohms to 66.67 milliohms.

F. Litmus Leakage Test.

1. The litmus test was used to determine electrolyte leakage at the terminal seals and welds after the overcharge tests.

2. The areas of closure of all cells were wiped with wet litmus paper at the completion of the Internal Resistance Test. Any discoloration of the litmus paper was considered as evidence of cell leakage and such cells were rejected.

3. There were 20 failures of the total of 221 cells subjected to the litmus test.

V. SECOND SECTION OF TEST.

A. General Performance Tests, the second section of the Sealed Nickel Cadmium Battery Test Program, are being conducted on five cells, the results of which will be summarized in the succeeding report.

APPENDIX

I. Table I contains cell dimensions and the results of the eight sections of the Acceptance Tests.

II. FIGURES.

A. Figure 1 is a photograph of the General Electric Company 3.0 ampere hour cell.

B. Figure 2 shows the characteristic two hour rate discharge curves.

C. Figure 3 shows the overcharge voltage curves.

TABLE I

CELL NUMBER	WEIGHT (GRAMS)	LENGTH (INCHES)	DIAMETER (INCHES)	CAPACITY TESTS			CHILL SHORT TEST	IMPRESSION SEAL TEST LEAKAGE	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	LITMUS LEAKAGE
				FIRST BY HAD CRANE	SECOND BY HAD CRANE	THIRD BY HAD CRANE							
4-96	158.7	3.09	1.25	4.08	3.87	4.08	1.20	NONE	1.41	1.43	1.47	28.07	NONE
7-56	160.0	3.10	1.24	4.02	3.60	3.68	1.20	NONE	1.44	1.45	1.48	14.04	NONE
3-104	157.6	3.13	1.25	4.01	3.86	3.75	1.21	NONE	1.42	1.46	1.44	17.54	NONE
3-117	156.5	3.10	1.25	4.01	3.90	3.83	1.21	NONE	1.41	1.47	1.45	21.05	NONE
3-100	159.5	3.09	1.24	3.93	3.78	3.70	1.21	NONE	1.41	1.44	1.44	24.56	NONE
5-46	155.2	3.10	1.25	3.93	3.71	3.80	1.20	NONE	1.44	1.45	1.47	14.04	NONE
5-48	159.0	3.10	1.25	3.93	3.71	3.80	1.20	NONE	1.44	1.45	1.47	14.04	NONE
7-51	156.4	3.10	1.24	3.93	3.48	3.53	1.19	NONE	1.44	1.44	1.47	14.04	NONE
3-112	154.5	3.11	1.25	3.90	3.80	3.75	1.21	NONE	1.42	1.47	1.47	17.54	NONE
3-123	153.4	3.11	1.25	3.90	3.72	3.65	1.21	NONE	1.44	1.48	1.48	28.07	NONE
5-28	159.4	3.10	1.25	3.90	3.68	3.83	1.20	NONE	1.44	1.46	1.47	14.04	NONE
5-29	154.4	3.12	1.25	3.90	3.72	3.83	1.20	NONE	1.44	1.45	1.47	17.54	NONE
5-39	157.0	3.09	1.25	3.90	3.68	3.80	1.20	NONE	1.44	1.45	1.47	14.04	NONE
5-41	158.3	3.10	1.25	3.90	3.68	3.78	1.19	NONE	1.44	1.45	1.47	14.04	NONE
5-49	156.0	3.09	1.25	3.90	3.63	3.75	1.20	NONE	1.44	1.45	1.47	14.04	NONE
5-27	157.7	3.11	1.25	3.87	3.71	3.80	1.20	NONE	1.44	1.46	1.47	14.04	NONE
5-34	158.4	3.12	1.25	3.87	3.63	3.75	1.20	NONE	1.44	1.45	1.47	17.54	NONE
5-40	157.3	3.10	1.25	3.87	3.75	3.78	1.20	NONE	1.44	1.45	1.47	7.02	NONE
5-50	154.0	3.09	1.25	3.87	3.65	3.78	1.20	NONE	1.44	1.45	1.47	10.53	NONE
3-53	154.0	3.11	1.25	3.86	3.25	3.50	1.20	NONE	1.45	1.49	1.49	24.56	NONE

TABLE 1 (CONTD)

CELL NUMBER	WEIGHT (GRAMS)	LENGTH (INCHES)	DIAMETER (INCHES)	CAPACITY TESTS			CELL SHORT TEST	IMERSION SEAL TEST LEAKAGE	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	LITMUS LEAKAGE
				FIRST BY NAD CRANE	SECOND BY NAD CRANE	THIRD BY NAD CRANE							
3-89	159.2	3.11	1.25	3.86	3.68	3.58	1.21	NONE	1.41	1.44	1.45	21.05	NONE
3-144	155.7	3.09	1.25	3.86	3.78	3.70	1.21	NONE	1.45	1.48	1.48	14.04	NONE
7-53	153.3	3.10	1.24	3.71	3.86	3.83	1.20	NONE	1.42	1.44	1.45	14.04	NONE
5-26	158.5	3.09	1.25	3.86	3.71	3.80	1.20	NONE	1.44	1.45	1.46	21.05	NONE
2-84	152.3	3.12	1.25	3.83	3.65	3.63	1.20	NONE	1.46	1.47	1.47	56.14	NONE
3-62	157.1	3.13	1.25	3.80	3.56	3.56	1.20	NONE	1.42	1.49	1.48	21.05	NONE
4-91	155.0	3.09	1.25	3.80	3.71	3.80	1.20	NONE	1.42	1.45	1.49	21.05	NONE
5-35	158.3	3.11	1.25	3.80	3.63	3.68	1.20	NONE	1.42	1.43	1.44	17.54	NONE
4-44	157.2	3.11	1.25	3.71	3.78	3.75	1.20	NONE	1.41	1.44	1.46	21.05	NONE
4-20	153.0	3.10	1.25	3.78	3.68	3.72	1.20	NONE	1.42	1.44	1.50	21.05	NONE
4-93	152.3	3.10	1.25	3.78	3.65	3.75	1.20	NONE	1.42	1.45	1.48	31.58	NONE
5-6	155.6	3.09	1.25	3.78	3.60	3.68	1.20	NONE	1.43	1.46	1.46	24.56	NONE
5-24	158.2	3.10	1.25	3.78	3.60	3.65	1.20	NONE	1.43	1.45	1.46	17.54	NONE
5-37	158.2	3.10	1.25	3.78	3.68	3.65	1.20	NONE	1.42	1.43	1.45	17.54	NONE
5-51	154.0	3.10	1.25	3.78	3.57	3.65	1.20	NONE	1.42	1.43	1.45	17.54	NONE
7-22	155.2	3.17	1.25	3.72	3.78	3.72	1.20	NONE	1.44	1.44	1.44	14.04	NONE
7-57	156.6	3.10	1.24	3.78	3.23	3.50	1.20	NONE	1.44	1.44	1.47	10.56	NONE
2-95	156.1	3.12	1.25	3.75	3.71	3.65	1.20	NONE	1.42	1.46	1.46	42.11	NONE
3-71	157.2	3.10	1.25	3.75	3.73	3.75	1.20	NONE	1.42	1.47	1.47	28.07	NONE
3-101	156.8	3.12	1.25	3.73	3.75	3.72	1.20	NONE	1.44	1.49	1.48	17.54	NONE

TABLE I (CONTD)

CELL NUMBER	WEIGHT (GRAMS)	LENGTH (INCHES)	DIAMETER (INCHES)	CAPACITY TESTS			CELL SHORT TEST	IMMERSION SEAL TEST LEAKAGE	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	LITRMS LEAKAGE
				FIRST BY NAD CRANE	SECOND BY NAD CRANE	THIRD BY NAD CRANE							
3-103	155.0	3.09	1.25	3.75	3.68	3.33	1.21	NONE	1.42	1.47	1.46	14.00	NONE
3-110	156.0	3.10	1.25	3.63	3.72	3.75	1.20	NONE	1.45	1.48	1.48	17.54	NONE
3-119	155.2	3.12	1.25	3.75	3.68	3.58	1.21	NONE	1.43	1.46	1.47	14.00	NONE
4-60	153.7	3.10	1.25	3.75	3.75	3.56	1.20	NONE	1.41	1.44	1.44	24.56	NONE
4-98	152.4	3.11	1.25	3.53	3.68	3.75	1.20	NONE	1.41	1.43	1.48	35.09	NONE
5-25	155.9	3.11	1.25	3.75	3.56	3.65	1.20	NONE	1.43	1.45	1.46	17.54	NONE
5-52	154.0	3.10	1.25	3.75	3.57	3.53	1.20	NONE	1.42	1.43	1.45	17.54	NONE
5-53	153.0	3.11	1.25	3.75	3.63	3.65	1.20	NONE	1.42	1.44	1.46	14.04	NONE
7-52	155.1	3.13	1.24	3.75	3.41	3.53	1.19	NONE	1.44	1.44	1.46	10.53	NONE
2-103	154.5	3.11	1.25	3.72	3.71	3.65	1.20	NONE	1.42	1.49	1.48	17.54	NONE
3-45	153.2	3.12	1.25	3.72	3.40	3.30	1.20	NONE	1.46	1.49	1.49	17.54	NONE
3-63	156.2	3.10	1.26	3.55	3.71	3.72	1.20	NONE	1.45	1.48	1.47	17.54	NONE
3-68	154.2	3.10	1.25	3.71	3.72	3.71	1.20	NONE	1.44	1.50	1.50	17.54	NONE
3-121	154.9	3.10	1.24	3.72	3.68	3.58	1.21	NONE	1.42	1.47	1.47	24.56	NONE
3-145	155.4	3.12	1.25	3.72	3.65	3.58	1.21	NONE	1.46	1.49	1.49	14.00	NONE
4-3	157.3	3.10	1.26	3.72	3.60	3.68	1.20	NONE	1.40	1.45	1.45	24.56	NONE
4-34	152.9	3.10	1.25	3.72	3.59	3.68	1.20	NONE	1.42	1.44	1.46	49.12	NONE
4-57	157.6	3.10	1.25	3.63	3.72	3.63	1.20	NONE	1.41	1.44	1.47	21.05	NONE
4-73	151.3	3.10	1.25	3.65	3.72	3.56	1.20	NONE	1.44	1.45	1.46	42.11	NONE
4-86	158.6	3.10	1.26	3.72	3.71	3.63	1.20	NONE	1.43	1.45	1.46	38.60	NONE

TABLE I (CONTD)

CELL NUMBER	WEIGHT (GRAMS)	LENGTH (INCHES)	DIAMETER (INCHES)	CAPACITY TESTS			GELL SHORT TEST	IMMERSION SEAL TEST LEAKAGE	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	LITMUS LEAKAGE
				FIRST BY MAD CRANE	SECOND BY MAD CRANE	THIRD BY MAD CRANE							
5-7	151.8	3.09	1.26	3.72	3.65	3.57	1.20	NONE	1.45	1.47	1.47	49.12	NONE
5-8	155.9	3.09	1.26	3.72	3.65	3.60	1.20	NONE	1.44	1.46	1.46	42.11	NONE
5-13	156.3	3.10	1.25	3.72	3.63	3.71	1.20	NONE	1.44	1.46	1.46	31.98	NONE
5-22	154.2	3.10	1.25	3.72	3.53	3.53	1.20	NONE	1.44	1.46	1.47	17.54	NONE
4-56	155.9	3.11	1.25	3.72	3.65	3.63	1.20	NONE	1.42	1.42	1.43	17.54	NONE
7-19	154.1	3.10	1.25	3.72	3.71	3.65	1.20	NONE	1.43	1.44	1.43	24.56	NONE
4-27	157.2	3.11	1.24	3.72	3.58	3.68	1.20	NONE	1.42	1.42	1.44	45.61	NONE
2-86	153.6	3.11	1.25	3.71	3.60	3.43	1.20	NONE	1.42	1.45	1.46	63.15	NONE
3-61	156.0	3.11	1.25	3.71	3.40	3.43	1.20	NONE	1.42	1.47	1.47	24.56	NONE
3-82	156.0	3.10	1.25	3.71	3.56	3.43	1.21	NONE	1.42	1.45	1.44	21.05	NONE
3-133	152.2	3.10	1.25	3.71	3.41	3.38	1.21	NONE	1.43	1.47	1.48	17.54	NONE
3-137	156.2	3.11	1.25	3.71	3.63	3.50	1.21	NONE	1.42	1.47	1.47	10.52	NONE
4-12	155.4	3.13	1.26	3.71	3.61	3.68	1.20	NONE	1.43	1.45	1.45	38.59	NONE
4-16	151.5	3.11	1.25	3.71	3.64	3.71	1.20	NONE	1.44	1.45	1.45	35.09	NONE
4-26	159.8	3.10	1.24	3.71	3.54	3.60	1.20	NONE	1.42	1.42	1.44	38.59	NONE
4-29	157.4	3.11	1.25	3.71	3.55	3.63	1.20	NONE	1.42	1.42	1.44	45.61	NONE
4-31	158.2	3.11	1.25	3.71	3.57	3.71	1.20	NONE	1.42	1.42	1.44	42.11	NONE
4-35	152.9	3.11	1.25	3.71	3.68	3.68	1.20	NONE	1.42	1.45	1.48	21.05	NONE
4-36	155.3	3.11	1.25	3.58	3.71	3.53	1.20	NONE	1.42	1.44	1.45	49.12	NONE
4-45	155.4	3.13	1.25	3.65	3.71	3.60	1.20	NONE	1.41	1.44	1.46	21.05	NONE

TABLE I (CONTD)

CELL NUMBER	WEIGHT (GRAMS)	LENGTH (INCHES)	DIAMETER (INCHES)	CAPACITY TESTS			CELL SHORT TEST	IMMERSTION SEAL TEST LEAKAGE	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	LITMUS LEAKAGE
				FIRST BY MAD CRANE	SECOND BY MAD CRANE	THIRD BY MAD CRANE							
4-99	154.0	3.09	1.25	3.48	3.65	3.71	1.20	NONE	1.42	1.44	1.49	31.58	NONE
3-57	158.9	3.10	1.25	3.65	3.71	3.63	1.20	NONE	1.44	1.43	1.50	14.04	NONE
5-10	154.6	3.09	1.26	3.71	3.60	3.48	1.20	NONE	1.45	1.47	1.46	42.11	NONE
5-16	156.4	3.09	1.25	3.71	3.53	3.60	1.20	NONE	1.44	1.45	1.46	24.56	NONE
7-18	155.0	3.09	1.25	3.71	3.68	3.57	1.20	NONE	1.44	1.44	1.43	24.56	NONE
7-37	161.4	3.12	1.25	3.71	3.45	3.45	1.19	NONE	1.44	1.44	1.45	17.54	NONE
7-39	154.1	3.11	1.24	3.71	3.53	3.48	1.20	NONE	1.44	1.44	1.45	21.05	NONE
7-40	156.1	3.10	1.25	3.71	3.23	3.20	1.19	NONE	1.43	1.45	1.47	14.04	NONE
1-95	149.4	3.10	1.25	3.68	3.60	3.57	1.20	NONE	1.46	1.48	1.48	45.61	NONE
2-9	151.0	3.10	1.25	3.68	3.63	3.55	1.20	NONE	1.42	1.46	1.46	42.11	NONE
2-67	152.6	3.10	1.25	3.68	3.53	3.56	1.20	NONE	1.46	1.48	1.48	66.67	NONE
3-78	142.2	3.12	1.24	3.68	3.53	3.43	1.21	NONE	1.42	1.47	1.45	31.57	NONE
3-107	154.5	3.11	1.26	3.45	3.68	3.68	1.20	NONE	1.44	1.48	1.48	17.54	NONE
4-14	156.2	3.10	1.26	3.68	3.59	3.63	1.20	NONE	1.42	1.44	1.45	28.07	NONE
4-17	153.2	3.10	1.25	3.68	3.63	3.68	1.20	NONE	1.44	1.45	1.45	24.56	NONE
4-32	156.5	3.11	1.25	3.68	3.55	3.65	1.20	NONE	1.42	1.42	1.44	42.11	NONE
4-47	156.3	3.11	1.26	3.68	3.65	3.48	1.20	NONE	1.42	1.43	1.43	17.54	NONE
4-51	155.9	3.08	1.26	3.58	3.68	3.56	1.20	NONE	1.42	1.43	1.44	10.53	NONE
4-79	155.9	3.11	1.25	3.65	3.68	3.57	1.20	NONE	1.41	1.43	1.47	24.56	NONE
4-85	156.2	3.10	1.25	3.65	3.68	3.57	1.20	NONE	1.43	1.45	1.46	38.60	NONE

TABLE I (CONTD)

CELL NUMBER	WEIGHT (GRAMS)	LENGTH (INCHES)	DIAMETER (INCHES)	CAPACITY TESTS			CELL SHORT TEST	IMMERSION SEAL TEST LEAKAGE	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	LITMUS LEAKAGE
				FIRST BY NAD CRANE	SECOND BY NAD CRANE	THIRD BY NAD CRANE							
5-17	155.9	3.11	1.25	3.68	3.42	3.48	1.20	NONE	1.44	1.46	1.47	21.05	NONE
5-20	153.2	3.10	1.25	3.68	3.56	3.53	1.20	NONE	1.44	1.45	1.46	28.07	NONE
5-21	155.1	3.09	1.25	3.68	3.48	3.50	1.20	NONE	1.44	1.45	1.47	17.54	NONE
5-23	155.6	3.09	1.25	3.68	3.45	3.50	1.20	NONE	1.44	1.46	1.46	17.54	NONE
7-8	158.5	3.11	1.25	3.68	3.56	3.53	1.20	NONE	1.42	1.43	1.44	21.05	NONE
7-9	156.7	3.10	1.25	3.68	3.57	3.56	1.20	NONE	1.42	1.43	1.44	17.54	NONE
7-14	155.5	3.10	1.25	3.68	3.63	3.57	1.20	NONE	1.42	1.43	1.42	14.04	NONE
7-17	153.3	3.10	1.25	3.68	3.65	3.60	1.20	NONE	1.44	1.44	1.43	14.04	NONE
7-36	156.9	3.10	1.24	3.68	3.42	3.48	1.19	NONE	1.43	1.44	1.45	14.04	NONE
7-44	152.0	3.10	1.25	3.68	3.42	3.45	1.19	NONE	1.44	1.45	1.46	14.04	NONE
2-3	150.1	3.10	1.25	3.65	3.63	3.58	1.20	NONE	1.43	1.47	1.46	52.63	NONE
2-6	150.8	3.09	1.25	3.65	3.60	3.58	1.20	NONE	1.42	1.46	1.46	35.09	NONE
2-97	151.8	3.11	1.25	3.65	3.65	3.60	1.20	NONE	1.42	1.46	1.46	52.63	NONE
3-44	157.8	3.10	1.25	3.65	3.63	3.60	1.20	NONE	1.43	1.50	1.50	14.04	NONE
3-111	155.6	3.10	1.26	3.60	3.65	3.65	1.20	NONE	1.44	1.48	1.48	17.54	NONE
3-122	152.6	3.10	1.25	3.65	3.56	3.50	1.21	NONE	1.43	1.47	1.47	24.56	NONE
3-132	155.4	3.12	1.25	3.65	3.56	3.45	1.21	NONE	1.43	1.48	1.48	31.57	NONE
3-136	155.2	3.12	1.25	3.65	3.56	3.55	1.21	NONE	1.42	1.46	1.46	14.00	NONE
4-2	158.0	3.08	1.25	3.65	3.60	3.63	1.20	NONE	1.42	1.44	1.47	21.05	NONE
4-8	156.1	3.10	1.24	3.65	3.59	3.60	1.20	NONE	1.42	1.44	1.45	35.09	NONE

TABLE 1 (CONTD)

CELL NUMBER	WEIGHT (GRAMS)	LENGTH (INCHES)	DIAMETER (INCHES)	CAPACITY TESTS			CELL SHORT TEST	IMERSION SEAL TEST	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	LITVUS LEAKAGE
				FIRST BY MAD CRANE	SECOND BY MAD CRANE	THIRD BY MAD CRANE							
4-11	155.0	3.10	1.25	3.65	3.60	3.63	1.20	NONE	1.42	1.45	1.48	24.56	NONE
4-13	156.7	3.11	1.26	3.65	3.57	3.63	1.20	NONE	1.42	1.44	1.45	38.59	NONE
4-15	155.5	3.10	1.25	3.65	3.57	3.50	1.20	NONE	1.42	1.44	1.48	17.54	NONE
4-21	155.6	3.10	1.26	3.65	3.51	3.63	1.20	NONE	1.43	1.44	1.45	35.09	NONE
4-33	152.9	3.11	1.25	3.65	3.51	3.60	1.20	NONE	1.42	1.43	1.45	35.09	NONE
4-40	153.8	3.09	1.25	3.55	3.65	3.48	1.20	NONE	1.43	1.43	1.44	21.05	NONE
4-43	160.3	3.10	1.27	3.55	3.65	3.42	1.20	NONE	1.42	1.43	1.44	17.54	NONE
4-49	155.7	3.10	1.25	3.65	3.60	3.53	1.20	NONE	1.41	1.44	1.48	21.05	NONE
5-2	153.6	3.09	1.26	3.65	3.65	3.50	1.20	NONE	1.45	1.46	1.46	42.11	NONE
7-10	157.8	3.11	1.25	3.65	3.56	3.57	1.20	NONE	1.42	1.42	1.44	14.04	NONE
7-11	155.0	3.09	1.25	3.65	3.50	3.50	1.20	NONE	1.43	1.43	1.43	21.05	NONE
7-21	149.8	3.11	1.25	3.65	3.65	3.60	1.20	NONE	1.44	1.44	1.44	59.65	NONE
7-31	155.5	3.10	1.24	3.63	3.65	3.50	1.19	NONE	1.43	1.44	1.46	7.02	NONE
7-32	155.9	3.10	1.24	3.65	3.33	3.56	1.19	NONE	1.43	1.44	1.46	17.54	NONE
7-43	159.1	3.08	1.24	3.65	3.23	3.50	1.19	NONE	1.44	1.44	1.46	17.54	NONE
7-47	160.7	3.10	1.24	3.65	3.41	3.53	1.19	NONE	1.43	1.44	1.45	10.56	NONE
4-58	159.90	3.10	1.25	3.65	3.60	3.53	1.20	NONE	1.42	1.43	1.43	17.54	NONE
2-21	151.7	3.15	1.25	3.63	3.56	3.50	1.20	NONE	1.42	1.46	1.46	35.09	NONE
2-98	155.1	3.11	1.25	3.63	3.60	3.58	1.20	NONE	1.42	1.47	1.46	17.54	NONE
3-109	154.7	3.11	1.25	3.63	3.53	3.43	1.21	NONE	1.45	1.48	1.48	17.54	NONE

TABLE I (CONTD)

CELL NUMBER	WEIGHT (GRAMS)	LENGTH (INCHES)	DIAMETER (INCHES)	CAPACITY TESTS			CELL SHORT TEST	IMERSION SEAL TEST LEAKAGE	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	LIT-40S LEAKAGE
				FIRST BY HAD CRANE	SECOND BY HAD CRANE	THIRD BY HAD CRANE							
3-131	155.6	3.11	1.25	3.63	3.38	3.25	1.21	NONE	1.42	1.47	1.47	28.07	NONE
4-4	157.0	3.11	1.25	3.63	3.50	3.57	1.20	NONE	1.42	1.45	1.45	28.07	NONE
4-5	154.0	3.09	1.26	3.63	3.51	3.60	1.20	NONE	1.42	1.45	1.45	28.07	NONE
4-7	154.8	3.10	1.25	3.63	3.56	3.63	1.20	NONE	1.43	1.46	1.45	38.59	NONE
4-9	159.0	3.12	1.26	3.63	3.56	3.60	1.20	NONE	1.42	1.44	1.45	24.56	NONE
4-41	157.0	3.11	1.27	3.53	3.63	3.42	1.20	NONE	1.42	1.43	1.43	21.05	NONE
4-53	158.4	3.11	1.27	3.53	3.63	3.50	1.20	NONE	1.43	1.44	1.44	17.54	NONE
4-64	157.1	3.11	1.25	3.63	3.57	3.56	1.20	NONE	1.41	1.42	1.47	24.56	NONE
4-66	153.9	3.12	1.25	3.60	3.63	3.53	1.20	NONE	1.41	1.44	1.48	24.56	NONE
4-67	155.3	3.11	1.25	3.60	3.63	3.53	1.20	NONE	1.41	1.44	1.48	21.05	NONE
4-77	153.4	3.11	1.26	3.57	3.63	3.56	1.20	NONE	1.44	1.46	1.46	42.11	NONE
6-88	155.5	3.11	1.25	3.63	3.60	3.56	1.19	NONE	1.42	1.44	1.45	17.54	NONE
7-12	151.9	3.08	1.25	3.63	3.60	3.56	1.20	NONE	1.43	1.43	1.43	14.04	NONE
7-15	156.8	3.09	1.25	3.63	3.63	3.56	1.20	NONE	1.42	1.43	1.43	14.04	NONE
7-16	153.6	3.10	1.25	3.63	3.60	3.60	1.20	NONE	1.43	1.44	1.44	17.54	NONE
7-35	155.8	3.11	1.24	3.63	3.42	3.48	1.19	NONE	1.44	1.44	1.46	14.04	NONE
7-49	157.9	3.11	1.24	3.63	3.53	3.56	1.19	NONE	1.44	1.44	1.46	10.56	NONE
2-34	152.0	3.11	1.25	3.60	3.53	3.43	1.20	NONE	1.42	1.46	1.46	42.11	NONE
2-104	155.3	3.11	1.25	3.60	3.57	3.48	1.20	NONE	1.42	1.49	1.49	14.03	NONE
3-75	156.9	3.11	1.25	3.60	3.35	3.60	1.20	NONE	1.42	1.49	1.49	31.57	NONE

TABLE I (CONTD)

CELL NUMBER	WEIGHT (GRAMS)	LENGTH (INCHES)	DIAMETER (INCHES)	CAPACITY TESTS			CELL SHORT TEST	IMMERSTION SEAL TEST LEAKAGE	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	LITMUS LEAKAGE
				FIRST BY NAD CRANE	SECOND BY NAD CRANE	THIRD BY NAD CRANE							
4-6	154.8	3.10	1.26	3.60	3.51	3.56	1.20	NONE	1.44	1.46	1.45	35.09	NONE
4-18	153.1	3.10	1.26	3.60	3.49	3.57	1.20	NONE	1.43	1.46	1.46	35.09	NONE
4-30	158.2	3.09	1.26	3.50	3.60	3.50	1.20	NONE	1.42	1.43	1.43	14.04	NONE
4-39	156.6	3.12	1.25	3.50	3.60	3.50	1.19	NONE	1.41	1.43	1.43	24.56	NONE
4-48	157.2	3.12	1.26	3.50	3.60	3.35	1.19	NONE	1.42	1.42	1.44	17.54	NONE
4-59	153.9	3.09	1.25	3.56	3.60	3.50	1.20	NONE	1.41	1.44	1.47	24.56	NONE
7-7	155.9	3.08	1.25	3.60	3.60	3.53	1.20	NONE	1.43	1.44	1.45	14.04	NONE
7-66	157.3	3.10	1.24	3.60	3.30	3.48	1.20	NONE	1.44	1.45	1.48	21.05	NONE
4-55	157.9	3.10	1.26	3.58	3.56	3.50	1.20	NONE	1.42	1.43	1.44	21.05	NONE
2-22	147.5	3.12	1.25	3.57	3.53	3.53	1.20	NONE	1.47	1.49	1.49	52.63	NONE
2-96	154.7	3.11	1.25	3.57	3.57	3.50	1.20	NONE	1.42	1.46	1.47	56.14	NONE
3-66	153.9	3.10	1.25	3.57	3.56	3.53	1.20	NONE	1.42	1.49	1.48	31.57	NONE
3-120	153.9	3.11	1.25	3.57	3.57	3.56	1.20	NONE	1.45	1.50	1.50	14.04	NONE
4-23	158.3	3.11	1.25	3.57	3.44	3.53	1.20	NONE	1.42	1.44	1.44	38.59	NONE
4-34	155.7	3.11	1.27	3.55	3.57	3.56	1.20	NONE	1.43	1.44	1.44	17.54	NONE
4-75	149.4	3.12	1.25	3.57	3.56	3.45	1.20	NONE	1.41	1.44	1.48	24.56	NONE
1-14	148.2	3.08	1.25	3.56	3.57	3.45	1.21	NONE	1.42	1.44	1.44	14.04	NONE
7-84	156.1	3.10	1.24	3.50	3.56	3.57	1.20	NONE	1.44	1.44	1.46	24.56	NONE
1-35	147.2	3.10	1.25	3.56	3.53	3.35	1.20	NONE	1.47	1.49	1.48	59.65	NONE
1-69	144.9	3.11	1.25	3.40	3.56	3.50	1.20	NONE	1.47	1.48	1.48	14.04	NONE

TABLE I (CONTD)

CELL NUMBER	WEIGHT (GRAMS)	LENGTH (INCHES)	DIAMETER (INCHES)	CAPACITY TESTS			CELL SHORT TEST	IMMERSION SEAL TEST LEAKAGE	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	LITMUS LEAKAGE
				FIRST BY NAD CRANE	SECOND BY NAD CRANE	THIRD BY NAD CRANE							
2-45	148.7	3.11	1.25	3.56	3.56	3.50	1.20	NONE	1.43	1.47	1.47	49.12	NONE
3-60	155.9	3.10	1.27	3.38	3.56	3.56	1.20	NONE	1.47	1.48	1.37	24.56	NONE
3-140	151.8	3.09	1.25	3.56	3.50	3.50	1.20	NONE	1.45	1.50	1.50	17.54	NONE
4-22	152.9	3.10	1.24	3.56	3.45	3.56	1.20	NONE	1.43	1.45	1.45	38.59	NONE
7-60	157.9	3.10	1.24	3.56	3.45	3.56	1.20	NONE	1.44	1.45	1.46	17.54	NONE
2-14	150.6	3.14	1.25	3.53	3.50	3.42	1.20	NONE	1.46	1.47	1.48	35.09	NONE
2-30	147.6	3.12	1.25	3.53	3.41	3.38	1.20	NONE	1.46	1.49	1.49	66.67	NONE
4-72	150.9	3.10	1.25	3.53	3.53	3.41	1.20	NONE	1.42	1.44	1.48	21.05	NONE
7-58	157.9	3.10	1.24	3.53	3.45	3.53	1.20	NONE	1.44	1.44	1.46	24.56	NONE
1-40	145.3	3.11	1.25	3.50	3.48	3.30	1.20	NONE	1.46	1.50	1.50	52.63	NONE
2-26	147.8	3.15	1.25	3.50	3.35	3.33	1.20	NONE	1.46	1.48	1.48	17.54	NONE
3-47	153.8	3.10	1.26	3.06	3.50	3.41	1.21	NONE	1.46	1.48	1.48	17.54	NONE
1-3	147.9	3.11	1.25	3.40	3.48	3.45	1.20	NONE	1.46	1.48	1.48	17.54	NONE
2-28	149.1	3.10	1.25	3.48	3.30	3.15	1.20	NONE	1.46	1.49	1.48	66.67	NONE
7-83	156.6	3.10	1.24	3.48	3.33	3.38	1.20	NONE	1.44	1.44	1.46	38.60	NONE
2-37	149.7	3.10	1.25	3.45	3.40	3.40	1.20	NONE	1.42	1.45	1.46	52.63	NONE
2-83	151.0	3.10	1.25	3.45	3.40	3.35	1.20	NONE	1.42	1.45	1.46	42.11	NONE
7-62	153.9	3.10	1.24	3.45	3.27	3.41	1.20	NONE	1.44	1.44	1.46	14.04	NONE
3-67	153.8	3.11	1.25	3.35	3.38	3.38	1.20	NONE	1.42	1.49	1.49	24.56	NONE
7-38	158.4	3.10	1.25	3.38	3.15	3.23	1.19	NONE	1.44	1.44	1.46	17.54	NONE

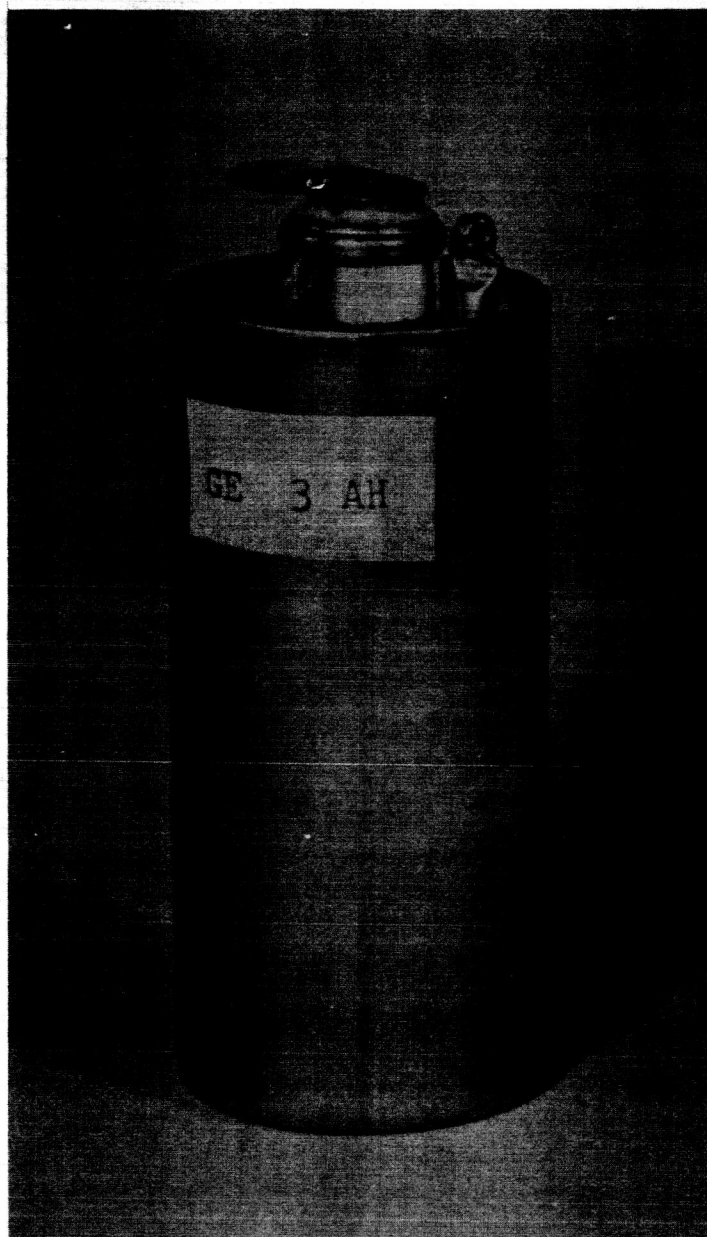


FIGURE 1

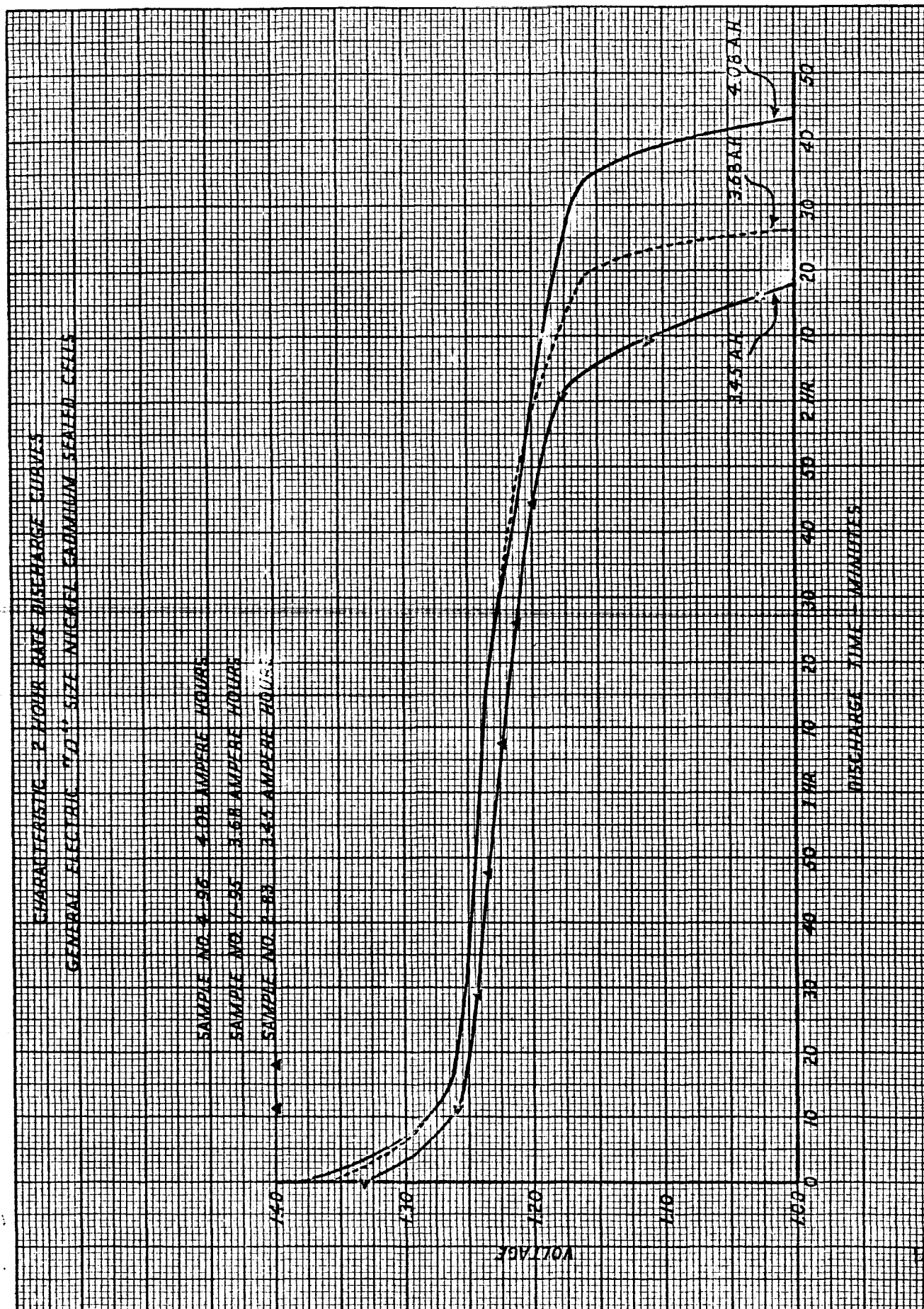


FIGURE 2

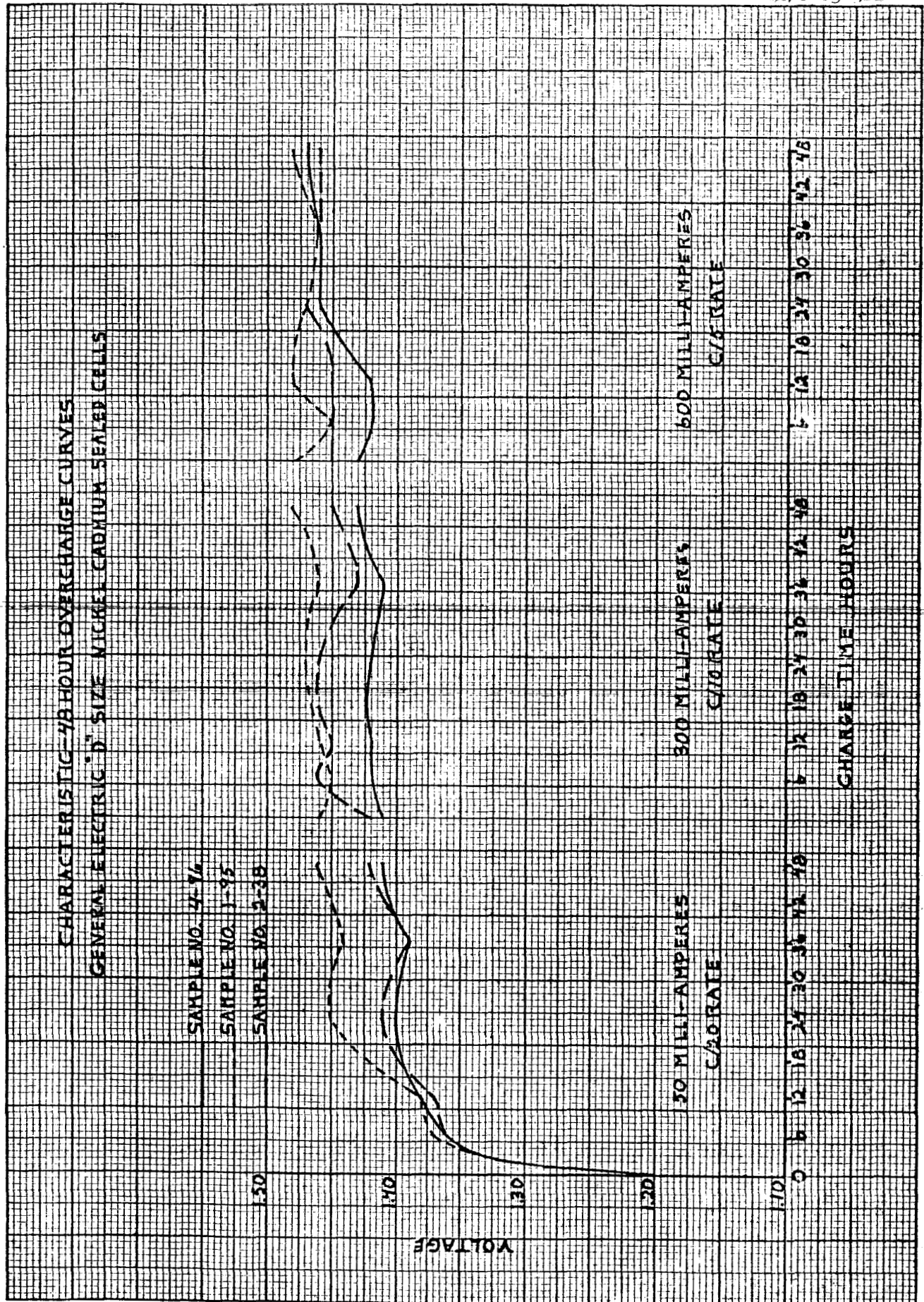



FIGURE 3

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- 51 General Electric Company, Battery Project, P. O. Box 114,
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- 52 - 56 General Electric Company, Battery Project, P. O. Box 114,
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